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EASTERN RESEARCH GROUP, INC.

MEMORANDUM

TO: Jim Eddinger, U.S. Environmental Protection Agency, OAQPS (C439-01)

FROM: Jason Huckaby, Eastern Research Group (ERG), Morrisville

DATE: October, 2002

SUBJECT: New Unit Analysis for Industrial, Commercial, and Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants

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1.0 INTRODUCTION

This memorandum describes the estimation of new boilers and process heaters projected to be built by 2005 and 2006 from the baseline year of 1998. The results of this analysis are used to estimate costs and impacts for new sources for a national emission standard for hazardous air pollutants (NESHAP) for industrial/commercial/institutional boilers and process heaters. The following table summarizes the results of the analysis. The years 2005 and 2006 were selected because they were five years from the expected proposal and promulgation dates of the boiler NESHAP.

Year	2005	2006
Industrial Boilers[a]	1660	2137
Commercial/Institutional Boilers[a]	1421	1548
Process Heaters[b]	1677	2043

[a] Industrial and commercial/institutional energy consumption forecasts were given separately. As a result, two unique forecasts were calculated. The expected number of new boilers is the sum of the values given for industrial and commercial/institutional (e.g., for year 2005, expected number of new boilers is 1660 + 1421 = 3081).

[b] Process heaters were assumed to be operated in industrial facilities only.

2.0 DATA SOURCES

Information used in this analysis consists of the model boilers developed for the cost and impacts analyses, and the fuel consumption outlook data for the industrial, commercial, and institutional sectors. The model boilers and their development are described in the memorandum *Development of Model Units for the Industrial/Commercial/Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants*[1]. The memorandum contains information on the average capacity, capacity utilization, percentage of each fuel burned, and number of boilers assigned to each model. The energy consumption forecasts were provided by the Energy Information Administration (EIA) of the U.S. Department of Energy[2]. The EIA provides forecasts of the fuel consumption of coal, biomass, residual oil, distillate oil, and natural gas from industrial and commercial boilers. However, it does not segregate biomass fired units from wood fired units. The EIA also does not contain information on other non-fossil fired units.

3.0 METHODOLOGY FOR ESTIMATING NEW UNITS

The methodology involved in this analysis consisted of two parts: 1) Calculating the predicted percent changes in fuel consumption in the industrial and commercial/institutional sectors, and 2) Calculating the expected fuel consumption in boilers and heaters and predicting the number of new units required to fire the fuel. The base year for this and all other analysis for the NESHAP is 1998. The steps required to perform this analysis are described below:

3.1 Calculating Percent Change in Fuel Consumption

The model unit memorandum provides the percentage of heat input for each model unit for the following fuel types: coal, wood, non-fossil fuel (NFF), biomass, natural gas, residual oil, and distillate oil. Projected fuel consumption by the industrial and commercial sectors for each of these fuels for 2005 and 2006 can then be used to calculate percent differences in fuel consumption.[2] The EIA fuel consumption projections, along with calculated percent differences for 2005 and 2006, are given in Table 3-1. These calculations were performed as follows:

- EIA data was gathered for industrial and commercial fuel use in the following fuel categories: steam coal, natural gas, residual fuel oil, distillate fuel oil, and biomass for 1998, 2005, and 2006.

- The following equation was applied to the EIA data to calculate the percent change from 1998 to other years:

$$PC\_x\_TY = \left(\left(EIA\_FC\_x\_TY - EIA\_FC\_x\_1998 \right) \Big/ EIA\_FC\_x\_1998 \right) \times 100$$

Where:
PC_x_TY = Percent change in consumption of fuel x for target year (2005 or 2006)
EIA_FC_x_TY = Consumption of fuel x from EIA data for the target year (2005 or 2006)
EIA_FC_x_1998 = Consumption of fuel x from EIA data for 1998

Because the wood fuel consumption could not be segregated from the biomass fuel consumption in the EIA data, the percent differences for both wood and biomass were calculated using the EIA's biomass fuel consumption data. Also, because the EIA data does not contain any information about other non-fossil fuel (NFF) consumption, it was assumed that NFF consumption would be constant (zero percent difference). Fuels with negative percent changes were assumed to have no change.

Table 3-1. Expected Fuel Consumption Differences by Sector [2]

Industrial Sector Fuel Consumption (Quadrillion Btu per year)				Percent Difference from 1998	
Fuel	1998	2005	2006	2005	2006
Natural Gas	9.75	10.36	10.56	6.3	8.3
Steam Coal	1.54	1.58	1.59	2.6	3.2
Residual oil	0.27	0.25	0.26	-7.4	-3.7
Distillate oil	1.08	1.21	1.24	12.0	14.8
Biomass	1.91	2.13	2.13	11.5	11.5
Commercial Sector Fuel Consumption (Quadrillion Btu per year)				**Percent Difference from 1998**	
Fuel	1998	2005	2006	2005	2006
Natural Gas	3.11	3.43	3.46	10.3	11.3
Coal	0.09	0.1	0.1	11.1	11.1
Residual oil	0.11	0.1	0.1	-9.1	-9.1
Distillate oil	0.38	0.38	0.38	0.0	0.0
Biomass	0.08	0.08	0.08	0.0	0.0

3.2 Fuel Consumption/ New boiler forecasting

To predict the number of new boilers and process heaters in operation by 2005 and 2006, the percent difference for each fuel calculated in 3.1 was applied to the fuel consumption of boilers and heaters represented by the models in the industrial and commercial/institutional sectors. This was done by using the following steps:

- First, the boilers assigned to the model were distributed between the industrial and commercial/institutional sectors. The distribution for each model was selected to represent the standard industrial classification (SIC) distributions of the existing boilers assigned to the model. Appendix A contains a table displaying the assumed percentages of each model that are used in industrial and commercial/institutional applications.

- Next, the annual fuel consumption from 1998 (MMBtu/yr) was calculated for each fuel segment (e.g., natural gas, coal, etc.) of each model by using the following equation:

$$FC\_x\_1998 = (AC)(CU)(N_{i,c})(FF\_x)(8760)$$

Where:

FC_x_1998 = Consumption of fuel x (e.g., natural gas) in 1998, MMBtu/yr
AC = average heat capacity of the model, MMBtu/hr
CU = fraction of boiler capacity that is used for the model
$N_{i,c}$ = number of boilers assigned to the model in the industrial or commercial/institutional sector
FF_x = fraction of fuel (coal, biomass, residual oil, distillate oil, or natural gas) fired by the model
8760 = hours per year

The fuel consumption values calculated for the model boilers and heaters in this step are then used as the 1998 basis for new unit predictions.

- Forecasts of annual fuel consumption for each fuel segment of each model were calculated for the target years (2005 or 2006) by applying the percent differences calculated in 3.1 to the 1998 fuel consumption calculated above. The formula used in this step is given as:

$$FC\_x\_TY = (FC\_x\_1998)\left(1 + \left(PC\_x\_TY / 100\right)\right)$$

Where:
FC_x_TY = Consumption of fuel x (e.g., natural gas) in target year (2005 or 2006, MMBtu/yr

This step resulted in fuel consumption forecasts (in MMBtu/yr) for each of the fuel categories for 2005 and 2006 for each model.

- Total fuel energy for each model (TFC_TY) was calculated by summing the fuel energy consumed for each of the five fuel sectors (natural gas, coal, wood, residual oil, and distillate oil).

$$TFC\_TY = \sum_{x=1}^{5} FC\_x\_TY$$

- The number units in the target year (NU_TY) was calculated using the equation

$$NU\_TY = \left(\frac{TFC\_TY}{(AC)(CU)(8760)} \right)$$

- The number of new units is calculated by subtracting the number of units in 1998 from the number of units in the target year.

The calculation procedures are illustrated in Appendix B.

4.0 RESULTS

The results of the new boiler analysis by model and year for the industrial and commercial sectors are presented in tables 4-1 and 4-2 respectively. The combined total number of new boilers for 2005 is expected to be 3081. Likewise, the total number of new industrial, commercial, and institutional boilers expected to be in use in 2006 is 3685. The largest number of new boilers are expected to be gas-fired. This is true for both industrial and commercial/institutional boilers.

Table 4-3 presents the results of the new process heater analysis by model and year. Unlike boilers, it was assumed that process heaters are predominantly used in industrial applications. Therefore, the predicted number of process heaters are based on EIA's industrial fuel consumption forecasts. It is expected that there will be 934 new process heaters by 2005, and 1234 new units by 2006. Like boilers, the majority of new process heaters are expected to be gas-fired units.

5.0 REFERENCES

1. Jeannette Alvis, Christy Burlew, and Roy Oommen, ERG. Memorandum to Jim Eddinger, U.S. Environmental Protection Agency, OAQPS. *Development of Model Units for the Industrial/Commercial/Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants.* October, 2002.

2. U.S. Department of Energy. Energy Information Administration. Annual Energy Outlook 2000. www.eia.doe/oiaf/archive/aeo00/aeotab_t.htm.

Table 4-1. New Boiler Analysis by Model and Year - Industrial

Model No	Material	Avg Capacity (MMBtu/hr)	Capacity Factor	1998 # of Boilers	2005		2006	
					Total Energy Consumed (MMBtu/yr)	# New Boilers	Total Energy Consumed (MMBtu/yr)	# New Boilers
1	Coal	4	0.6	62	1.34E+06	2	1.35E+06	2
2	Coal	54	0.6	689	2.01E+08	18	2.02E+08	22
3	Coal	166	0.6	382	3.42E+08	10	3.44E+08	12
4	Coal	565	0.6	153	4.66E+08	4	4.69E+08	5
5	Coal	2	0.6	9	9.71E+04	0	9.77E+04	0
6	Coal	57	0.6	74	2.26E+07	2	2.27E+07	2
7	Coal	186	0.6	159	1.59E+08	4	1.60E+08	5
8	Coal	600	0.6	218	7.06E+08	6	7.11E+08	7
9	Coal/Wood/NFF Liquid/NFF Solid	6	0.57	6	1.80E+05	0	1.80E+05	0
10	Coal/Wood/NFF Liquid/NFF Solid	35	0.7	54	1.23E+07	4	1.24E+07	4
11	Coal/Wood/NFF Liquid/NFF Solid	173	0.76	14	1.78E+07	1	1.78E+07	1
12	Coal/Wood/NFF Liquid/NFF Solid	565	0.83	62	2.71E+08	4	2.72E+08	5
13	Gas	3	0.62	11,294	1.96E+08	707	1.99E+08	938
14	Gas	33	0.63	6,023	1.17E+09	377	1.19E+09	500
15	Gas	164	0.64	666	6.51E+08	42	6.63E+08	55
16	Gas	520	0.71	300	1.03E+09	19	1.05E+09	25
17	Gas/Wood/Other Biomass/Liquid FF	6	0.57	20	6.61E+05	2	6.63E+05	2
18	Gas/Wood/Other Biomass/Liquid FF	45	0.67	78	2.26E+07	8	2.27E+07	8
19	Gas/Wood/Other Biomass/Liquid FF	178	0.77	27	3.60E+07	3	3.61E+07	3
20	Gas/Wood/Other Biomass/Liquid FF	394	0.8	36	1.10E+08	4	1.10E+08	4
21	Distillate Liquid FF	3	0.6	1,177	2.08E+07	142	2.13E+07	174
22	Distillate Liquid FF	29	0.6	488	8.34E+07	59	8.55E+07	72
23	Distillate Liquid FF	157	0.6	54	4.99E+07	6	5.12E+07	8
24	Distillate Liquid FF	355	0.6	34	7.02E+07	4	7.20E+07	5
25	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	6	0.62	6	2.01E+05	0	2.02E+05	0
26	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	58	0.69	53	1.91E+07	1	1.92E+07	2
27	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	161	0.64	34	3.15E+07	1	3.17E+07	1
28	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	562	0.75	22	8.33E+07	1	8.40E+07	1
29	Wood	5	0.57	125	3.47E+06	14	3.47E+06	14
30	Wood	30	0.64	298	5.58E+07	34	5.58E+07	34
31	Wood	179	0.78	50	6.77E+07	6	6.77E+07	6
32	Wood	449	0.8	19	6.74E+07	2	6.74E+07	2
33	Wood	7	0.56	12	4.60E+05	1	4.60E+05	1
34	Wood	26	0.72	26	4.68E+06	3	4.68E+06	3
35	Wood	677	0.7	2	7.41E+06	0	7.41E+06	0
36	Wood/Other Biomass/NFF Liquid/NFF Solid	7	0.68	9	4.02E+05	1	4.02E+05	1
37	Wood/Other Biomass/NFF Liquid/NFF Solid	44	0.64	26	6.92E+06	2	6.92E+06	2

Table 4-1. New Boiler Analysis by Model and Year - Industrial (Continued)

Model No	Material	Avg Capacity (MMBtu/hr)	Capacity Factor	1998 # of Boilers	2005 Total Energy Consumed (MMBtu/yr)	2005 # New Boilers	2006 Total Energy Consumed (MMBtu/yr)	2006 # New Boilers
38	Wood/Other Biomass/NFF Liquid/NFF Solid	173	0.82	30	4.14E+07	3	4.14E+07	3
39	Wood/Other Biomass/NFF Liquid/NFF Solid	513	0.79	53	2.05E+08	5	2.05E+08	5
40	Residual Liquid FF	3	0.6	358	5.22E+06	-27	5.43E+06	-13
41	Residual Liquid FF	37	0.6	866	1.56E+08	-64	1.62E+08	-32
42	Residual Liquid FF	172	0.6	198	1.66E+08	-15	1.72E+08	-7
43	Residual Liquid FF	547	0.6	106	2.82E+08	-8	2.93E+08	-4
44	Bagasse/Other	72	0.67	36	1.69E+07	4	1.69E+07	4
45	Bagasse/Other	158	0.82	36	4.54E+07	4	4.54E+07	4
46	Bagasse/Other	419	0.8	60	1.96E+08	7	1.96E+08	7
47	Coal	4	0.1	27	9.71E+04	1	9.77E+04	1
48	Coal	54	0.1	53	2.55E+06	1	2.56E+06	2
49	Coal	466	0.1	22	9.11E+06	1	9.17E+06	1
50	Coal	565	0.1	5	2.67E+06	0	2.68E+06	0
52	Coal	57	0.1	24	1.23E+06	1	1.24E+06	1
53	Coal	186	0.1	7	1.13E+06	0	1.14E+06	0
54	Coal	600	0.1	11	6.07E+06	0	6.10E+06	0
55	Coal/Wood/NFF Liquid/NFF Solid	6	0.1	1	4.51E+03	0	4.52E+03	0
56	Coal/Wood/NFF Liquid/NFF Solid	35	0.1	2	5.26E+04	0	5.27E+04	0
57	Coal/Wood/NFF Liquid/NFF Solid	173	0.1	1	1.30E+05	0	1.30E+05	0
58	Gas	3	0.1	967	2.70E+06	60	2.75E+06	80
59	Gas	33	0.1	359	1.10E+07	22	1.13E+07	30
60	Gas	164	0.1	47	7.14E+06	3	7.28E+06	4
61	Gas	520	0.1	16	7.55E+06	1	7.70E+06	1
62	Gas/Wood/Other Biomass/Liquid FF	6	0.1	2	9.27E+03	0	9.30E+03	0
63	Gas/Wood/Other Biomass/Liquid FF	45	0.1	2	1.04E+05	0	1.05E+05	0
64	Gas/Wood/Other Biomass/Liquid FF	178	0.1	2	2.75E+05	0	2.76E+05	0
65	Gas/Wood/Other Biomass/Liquid FF	394	0.1	1	3.04E+05	0	3.05E+05	0
66	Distillate Liquid FF	3	0.1	244	7.19E+05	29	7.37E+05	36
67	Distillate Liquid FF	29	0.1	126	3.59E+06	15	3.68E+06	19
68	Distillate Liquid FF	157	0.1	25	3.88E+06	3	3.98E+06	4
69	Distillate Liquid FF	355	0.1	8	2.72E+06	1	2.78E+06	1
70	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	58	0.1	3	1.56E+05	0	1.58E+05	0
72	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	562	0.1	1	5.05E+05	0	5.09E+05	0
73	Wood	5	0.1	11	5.47E+04	1	5.47E+04	1
74	Wood	30	0.1	6	1.88E+05	1	1.88E+05	1
75	Wood	179	0.1	1	1.40E+05	0	1.40E+05	0
76	Wood	7	0.1	2	1.64E+04	0	1.64E+04	0
77	Wood	26	0.1	2	4.06E+04	0	4.06E+04	0
78	Wood/Other Biomass/NFF Liquid/NFF Solid	7	0.1	2	1.07E+04	0	1.07E+04	0

Table 4-1. New Boiler Analysis by Model and Year - Industrial (Continued)

Model No	Material	Avg Capacity (MMBtu/hr)	Capacity Factor	1998 # of Boilers	2005		2006	
					Total Energy Consumed (MMBtu/yr)	# New Boilers	Total Energy Consumed (MMBtu/yr)	# New Boilers
79	Wood/Other Biomass/NFF Liquid/NFF Solid	44	0.1	3	1.35E+05	0	1.35E+05	0
80	Residual Liquid FF	3	0.1	119	2.90E+05	-9	3.02E+05	-4
81	Residual Liquid FF	37	0.1	228	6.84E+06	-17	7.12E+06	-8
82	Residual Liquid FF	172	0.1	47	6.59E+06	-4	6.86E+06	-2
83	Residual Liquid FF	547	0.1	5	2.33E+06	0	2.42E+06	0
					Total New Boilers*	**1660**		**2137**

* Negative values for residual oil were assumed to be zero.

Table 4-2. New Boiler Analysis by Model and Year - Commercial

Model No.	Material	Avg Capacity (MMBtu/hr)	Capacity Factor	1998 # of Boilers	2005		2006	
					Total Energy Consumed (MMBtu/yr)	# New Boilers	Total Energy Consumed (MMBtu/yr)	# New Boilers
1	Coal	4	0.6	21	4.85E+05	2	4.85E+05	2
2	Coal	54	0.6	230	7.25E+07	26	7.25E+07	26
3	Coal	166	0.6	127	1.23E+08	14	1.23E+08	14
4	Coal	565	0.6	51	1.68E+08	6	1.68E+08	6
5	Coal	2	0.6	3	3.50E+04	0	3.50E+04	0
6	Coal	57	0.6	25	8.16E+06	3	8.16E+06	3
7	Coal	186	0.6	53	5.76E+07	6	5.76E+07	6
8	Coal	600	0.6	73	2.55E+08	8	2.55E+08	8
9	Coal/Wood/NFF Liquid/NFF Solid	6	0.57	1	4.39E+04	0	4.39E+04	0
10	Coal/Wood/NFF Liquid/NFF Solid	35	0.7	13	3.01E+06	1	3.01E+06	1
11	Coal/Wood/NFF Liquid/NFF Solid	173	0.76	4	4.34E+06	0	4.34E+06	0
12	Coal/Wood/NFF Liquid/NFF Solid	565	0.83	15	6.62E+07	1	6.62E+07	1
13	Gas	3	0.62	7,530	1.35E+08	775	1.36E+08	847
14	Gas	33	0.63	4,016	8.07E+08	413	8.14E+08	452
15	Gas	164	0.64	444	4.50E+08	46	4.54E+08	50
16	Gas	520	0.71	200	7.13E+08	21	7.20E+08	23
17	Gas/Wood/Other Biomass/Liquid FF	6	0.57	5	1.51E+05	0	1.51E+05	0
18	Gas/Wood/Other Biomass/Liquid FF	45	0.67	19	5.16E+06	0	5.16E+06	0
19	Gas/Wood/Other Biomass/Liquid FF	178	0.77	7	8.22E+06	0	8.23E+06	0
20	Gas/Wood/Other Biomass/Liquid FF	394	0.8	9	2.50E+07	0	2.50E+07	0
21	Distillate Liquid FF	3	0.6	784	1.24E+07	0	1.24E+07	0
22	Distillate Liquid FF	29	0.6	326	4.96E+07	0	4.96E+07	0
23	Distillate Liquid FF	157	0.6	36	2.97E+07	0	2.97E+07	0
24	Distillate Liquid FF	355	0.6	22	4.18E+07	0	4.18E+07	0
25	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	6	0.62	0	0.00E+00	0	0.00E+00	0
26	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	58	0.69	0	0.00E+00	0	0.00E+00	0
27	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	161	0.64	0	0.00E+00	0	0.00E+00	0
28	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	562	0.75	0	0.00E+00	0	0.00E+00	0
29	Wood	5	0.57	31	7.79E+05	0	7.79E+05	0
30	Wood	30	0.64	74	1.25E+07	0	1.25E+07	0
31	Wood	179	0.78	12	1.52E+07	0	1.52E+07	0
32	Wood	449	0.8	5	1.51E+07	0	1.51E+07	0
33	Wood	7	0.56	3	1.03E+05	0	1.03E+05	0
34	Wood	26	0.72	6	1.05E+06	0	1.05E+06	0
35	Wood	677	0.7	0	1.66E+06	0	1.66E+06	0

Table 4-2. New Boiler Analysis by Model and Year - Commercial (Continued)

Model No.	Material	Avg Capacity (MMBtu/hr)	Capacity Factor	1998 # of Boilers	2005 Total Energy Consumed (MMBtu/yr)	2005 # New Boilers	2006 Total Energy Consumed (MMBtu/yr)	2006 # New Boilers
36	Wood/Other Biomass/NFF Liquid/NFF Solid	7	0.68	2	9.17E+04	0	9.17E+04	0
37	Wood/Other Biomass/NFF Liquid/NFF Solid	44	0.64	6	1.58E+06	0	1.58E+06	0
38	Wood/Other Biomass/NFF Liquid/NFF Solid	173	0.82	8	9.44E+06	0	9.44E+06	0
39	Wood/Other Biomass/NFF Liquid/NFF Solid	513	0.79	13	4.69E+07	0	4.69E+07	0
40	Residual Liquid FF	3	0.6	119	1.71E+06	-11	1.71E+06	-11
41	Residual Liquid FF	37	0.6	289	5.10E+07	-26	5.10E+07	-26
42	Residual Liquid FF	172	0.6	66	5.42E+07	-6	5.42E+07	-6
43	Residual Liquid FF	547	0.6	35	9.21E+07	-3	9.21E+07	-3
44	Bagasse/Other	72	0.67	0	0.00E+00	0	0.00E+00	0
45	Bagasse/Other	158	0.82	0	0.00E+00	0	0.00E+00	0
46	Bagasse/Other	419	0.8	0	0.00E+00	0	0.00E+00	0
47	Coal	4	0.1	9	3.50E+04	1	3.50E+04	1
48	Coal	54	0.1	18	9.20E+05	2	9.20E+05	2
49	Coal	466	0.1	7	3.29E+06	1	3.29E+06	1
50	Coal	565	0.1	2	9.62E+05	0	9.62E+05	0
52	Coal	57	0.1	8	4.44E+05	1	4.44E+05	1
53	Coal	186	0.1	2	4.07E+05	0	4.07E+05	0
54	Coal	600	0.1	4	2.19E+06	0	2.19E+06	0
55	Coal/Wood/NFF Liquid/NFF Solid	6	0.1	0	1.10E+03	0	1.10E+03	0
56	Coal/Wood/NFF Liquid/NFF Solid	35	0.1	0	1.28E+04	0	1.28E+04	0
57	Coal/Wood/NFF Liquid/NFF Solid	173	0.1	0	3.17E+04	0	3.17E+04	0
58	Gas	3	0.1	644	1.87E+06	66	1.88E+06	73
59	Gas	33	0.1	240	7.64E+06	25	7.71E+06	27
60	Gas	164	0.1	31	4.94E+06	3	4.99E+06	4
61	Gas	520	0.1	10	5.22E+06	1	5.27E+06	1
62	Gas/Wood/Other Biomass/Liquid FF	6	0.1	0	2.12E+03	0	2.12E+03	0
63	Gas/Wood/Other Biomass/Liquid FF	45	0.1	1	2.38E+04	0	2.38E+04	0
64	Gas/Wood/Other Biomass/Liquid FF	178	0.1	0	6.28E+04	0	6.28E+04	0
65	Gas/Wood/Other Biomass/Liquid FF	394	0.1	0	6.95E+04	0	6.96E+04	0
66	Distillate Liquid FF	3	0.1	163	4.28E+05	0	4.28E+05	0
67	Distillate Liquid FF	29	0.1	84	2.13E+06	0	2.13E+06	0
68	Distillate Liquid FF	157	0.1	17	2.31E+06	0	2.31E+06	0
69	Distillate Liquid FF	355	0.1	5	1.62E+06	0	1.62E+06	0
70	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	58	0.1	0	0.00E+00	0	0.00E+00	0
72	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	562	0.1	0	0.00E+00	0	0.00E+00	0

Table 4-2. New Boiler Analysis by Model and Year - Commercial (Continued)

Model No.	Material	Avg Capacity (MMBtu/hr)	Capacity Factor	1998 # of Boilers	2005 Total Energy Consumed (MMBtu/yr)	2005 # New Boilers	2006 Total Energy Consumed (MMBtu/yr)	2006 # New Boilers
73	Wood	5	0.1	3	1.23E+04	0	1.23E+04	0
74	Wood	30	0.1	2	4.20E+04	0	4.20E+04	0
75	Wood	179	0.1	0	3.14E+04	0	3.14E+04	0
76	Wood	7	0.1	1	3.68E+03	0	3.68E+03	0
77	Wood	26	0.1	0	9.11E+03	0	9.11E+03	0
78	Wood/Other Biomass/NFF Liquid/NFF Solid	7	0.1	0	2.45E+03	0	2.45E+03	0
79	Wood/Other Biomass/NFF Liquid/NFF Solid	44	0.1	1	3.08E+04	0	3.08E+04	0
80	Residual Liquid FF	3	0.1	40	9.50E+04	-4	9.50E+04	-4
81	Residual Liquid FF	37	0.1	76	2.24E+06	-7	2.24E+06	-7
82	Residual Liquid FF	172	0.1	16	2.16E+06	-1	2.16E+06	-1
83	Residual Liquid FF	547	0.1	2	7.62E+05	0	7.62E+05	0
					Total New Boilers*	1421		1548

* Negative values for residual oil were assumed to be zero.

Table 4-3. New Heaters

Model No.	Material	Avg Capacity (MMBtu/hr)	2005		2006	
			Total Energy Consumed (MMBtu/yr)	# New Heaters	Total Energy Consumed (MMBtu/yr)	# New Heaters
1	Coal	4	0.00E+00	0	0.00E+00	0
2	Coal	54	0.00E+00	0	0.00E+00	0
3	Coal	166	0.00E+00	0	0.00E+00	0
4	Coal	565	0.00E+00	0	0.00E+00	0
5	Coal	2	0.00E+00	0	0.00E+00	0
6	Coal	57	0.00E+00	0	0.00E+00	0
7	Coal	186	0.00E+00	0	0.00E+00	0
8	Coal	600	0.00E+00	0	0.00E+00	0
9	Coal/Wood/NFF Liquid/NFF Solid	6	0.00E+00	0	0.00E+00	0
10	Coal/Wood/NFF Liquid/NFF Solid	35	0.00E+00	0	0.00E+00	0
11	Coal/Wood/NFF Liquid/NFF Solid	173	0.00E+00	0	0.00E+00	0
12	Coal/Wood/NFF Liquid/NFF Solid	565	0.00E+00	0	0.00E+00	0
13	Gas	3	1.49E+08	538	1.52E+08	714
14	Gas	33	8.08E+08	261	8.23E+08	347
15	Gas	164	4.96E+08	32	5.06E+08	42
16	Gas	520	6.87E+08	13	7.01E+08	17
17	Gas/Wood/Other Biomass/Liquid FF	6	0.00E+00	0	0.00E+00	0
18	Gas/Wood/Other Biomass/Liquid FF	45	0.00E+00	0	0.00E+00	0
19	Gas/Wood/Other Biomass/Liquid FF	178	0.00E+00	0	0.00E+00	0
20	Gas/Wood/Other Biomass/Liquid FF	394	0.00E+00	0	0.00E+00	0
21	Distillate Liquid FF	3	3.29E+06	22	3.37E+06	28
22	Distillate Liquid FF	29	1.72E+07	12	1.77E+07	15
23	Distillate Liquid FF	157	1.39E+07	2	1.42E+07	2
24	Distillate Liquid FF	355	1.07E+08	6	1.09E+08	8
25	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	6	1.34E+05	0	1.35E+05	0
26	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	58	1.08E+06	0	1.09E+06	0
27	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	161	3.70E+06	0	3.73E+06	0
28	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	562	0.00E+00	0	0.00E+00	0
29	Wood	5	2.23E+05	1	2.23E+05	1
30	Wood	30	6.38E+06	4	6.38E+06	4
31	Wood	179	0.00E+00	0	0.00E+00	0
32	Wood	449	0.00E+00	0	0.00E+00	0
33	Wood	7	0.00E+00	0	0.00E+00	0
34	Wood	26	0.00E+00	0	0.00E+00	0
35	Wood	677	0.00E+00	0	0.00E+00	0
36	Wood/Other Biomass/NFF Liquid/NFF Solid	7	0.00E+00	0	0.00E+00	0
37	Wood/Other Biomass/NFF Liquid/NFF Solid	44	0.00E+00	0	0.00E+00	0

Table 4-3. New Heaters (Continued)

Model No.	Material	Avg Capacity (MMBtu/hr)	2005		2006	
			Total Energy Consumed (MMBtu/yr)	# New Heaters	Total Energy Consumed (MMBtu/yr)	# New Heaters
38	Wood/Other Biomass/NFF Liquid/NFF Solid	173	0.00E+00	0	0.00E+00	0
39	Wood/Other Biomass/NFF Liquid/NFF Solid	513	0.00E+00	0	0.00E+00	0
40	Residual Liquid FF	3	1.10E+06	-6	1.14E+06	-3
41	Residual Liquid FF	37	9.29E+07	-38	9.66E+07	-19
42	Residual Liquid FF	172	5.52E+07	-5	5.75E+07	-2
43	Residual Liquid FF	547	4.53E+07	-1	4.71E+07	-1
44	Bagasse/Other	72	0.00E+00	0	0.00E+00	0
45	Bagasse/Other	158	0.00E+00	0	0.00E+00	0
46	Bagasse/Other	419	0.00E+00	0	0.00E+00	0
47	Coal	4	0.00E+00	0	0.00E+00	0
48	Coal	54	0.00E+00	0	0.00E+00	0
49	Coal	466	0.00E+00	0	0.00E+00	0
50	Coal	565	0.00E+00	0	0.00E+00	0
52	Coal	57	0.00E+00	0	0.00E+00	0
53	Coal	186	0.00E+00	0	0.00E+00	0
54	Coal	600	0.00E+00	0	0.00E+00	0
55	Coal/Wood/NFF Liquid/NFF Solid	6	0.00E+00	0	0.00E+00	0
56	Coal/Wood/NFF Liquid/NFF Solid	35	0.00E+00	0	0.00E+00	0
57	Coal/Wood/NFF Liquid/NFF Solid	173	0.00E+00	0	0.00E+00	0
58	Gas	3	1.06E+06	24	1.08E+06	31
59	Gas	33	6.76E+06	14	6.89E+06	18
60	Gas	164	1.83E+06	1	1.87E+06	1
61	Gas	520	6.78E+06	1	6.91E+06	1
62	Gas/Wood/Other Biomass/Liquid FF	6	0.00E+00	0	0.00E+00	0
63	Gas/Wood/Other Biomass/Liquid FF	45	0.00E+00	0	0.00E+00	0
64	Gas/Wood/Other Biomass/Liquid FF	178	0.00E+00	0	0.00E+00	0
65	Gas/Wood/Other Biomass/Liquid FF	394	0.00E+00	0	0.00E+00	0
66	Distillate Liquid FF	3	6.18E+04	3	6.34E+04	3
67	Distillate Liquid FF	29	2.28E+05	1	2.33E+05	1
68	Distillate Liquid FF	157	1.54E+05	0	1.58E+05	0
69	Distillate Liquid FF	355	3.48E+05	0	3.57E+05	0
70	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	58	5.21E+04	0	5.25E+04	0
72	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	562	0.00E+00	0	0.00E+00	0
73	Wood	5	0.00E+00	0	0.00E+00	0
74	Wood	30	0.00E+00	0	0.00E+00	0
75	Wood	179	0.00E+00	0	0.00E+00	0
76	Wood	7	0.00E+00	0	0.00E+00	0
77	Wood	26	0.00E+00	0	0.00E+00	0

Table 4-3. New Heaters (Continued)

Model No.	Material	Avg Capacity (MMBtu/hr)	2005		2006	
			Total Energy Consumed (MMBtu/yr)	# New Heaters	Total Energy Consumed (MMBtu/yr)	# New Heaters
78	Wood/Other Biomass/NFF Liquid/NFF Solid	7	0.00E+00	0	0.00E+00	0
79	Wood/Other Biomass/NFF Liquid/NFF Solid	44	0.00E+00	0	0.00E+00	0
80	Residual Liquid FF	3	1.95E-04	-1	2.02E-04	0
81	Residual Liquid FF	37	6.90E+05	-2	7.18E+05	-1
82	Residual Liquid FF	172	0.00E+00	0	0.00E+00	0
83	Residual Liquid FF	547	0.00E+00	0	0.00E+00	0
			Total New Heaters	**934**		**1234**

Note: Analysis assumes that all process heaters are used in industrial applications.

* Negative values for residual oil-fired units were assumed to be zero.

Appendix A

Distribution of Model Boiler Units Between Industrial and Commercial/Institutional Sectors

(See Excel spreadsheet "NewunitappA.xls")

Appendix A. Assigned Distribution of Industrial and Commercial/Institutional Units

Model No	Material	Total Units Assigned to Model	Percentage Industrial	Percentage Commercial/ Institutional
1	Coal	83	75	25
2	Coal	919	75	25
3	Coal	509	75	25
4	Coal	204	75	25
5	Coal	12	75	25
6	Coal	98	75	25
7	Coal	212	75	25
8	Coal	291	75	25
9	Coal/Wood/NFF Liquid/NFF Solid	7	80	20
10	Coal/Wood/NFF Liquid/NFF Solid	67	80	20
11	Coal/Wood/NFF Liquid/NFF Solid	18	80	20
12	Coal/Wood/NFF Liquid/NFF Solid	77	80	20
13	Gas	18,824	60	40
14	Gas	10,039	60	40
15	Gas	1,110	60	40
16	Gas	500	60	40
17	Gas/Wood/Other Biomass/Liquid FF	25	80	20
18	Gas/Wood/Other Biomass/Liquid FF	97	80	20
19	Gas/Wood/Other Biomass/Liquid FF	34	80	20
20	Gas/Wood/Other Biomass/Liquid FF	45	80	20
21	Distillate Liquid FF	1,961	60	40
22	Distillate Liquid FF	814	60	40
23	Distillate Liquid FF	90	60	40
24	Distillate Liquid FF	56	60	40
25	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	6	100	0
26	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	53	100	0
27	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	34	100	0
28	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	22	100	0
29	Wood	156	80	20
30	Wood	372	80	20
31	Wood	62	80	20
32	Wood	24	80	20
33	Wood	15	80	20
34	Wood	32	80	20
35	Wood	2	80	20
36	Wood/Other Biomass/NFF Liquid/NFF Solid	11	80	20
37	Wood/Other Biomass/NFF Liquid/NFF Solid	32	80	20
38	Wood/Other Biomass/NFF Liquid/NFF Solid	38	80	20
39	Wood/Other Biomass/NFF Liquid/NFF Solid	66	80	20
40	Residual Liquid FF	477	75	25
41	Residual Liquid FF	1,154	75	25
42	Residual Liquid FF	264	75	25
43	Residual Liquid FF	141	75	25
44	Bagasse/Other	36	100	0
45	Bagasse/Other	36	100	0
46	Bagasse/Other	60	100	0

Appendix A. Assigned Distribution of Industrial and Commercial/Institutional Units

Model No	Material	Total Units Assigned to Model	Percentage Industrial	Percentage Commercial/ Institutional
47	Coal	36	75	25
48	Coal	70	75	25
49	Coal	29	75	25
50	Coal	7	75	25
52	Coal	32	75	25
53	Coal	9	75	25
54	Coal	15	75	25
55	Coal/Wood/NFF Liquid/NFF Solid	1	80	20
56	Coal/Wood/NFF Liquid/NFF Solid	2	80	20
57	Coal/Wood/NFF Liquid/NFF Solid	1	80	20
58	Gas	1,611	60	40
59	Gas	599	60	40
60	Gas	78	60	40
61	Gas	26	60	40
62	Gas/Wood/Other Biomass/Liquid FF	2	80	20
63	Gas/Wood/Other Biomass/Liquid FF	3	80	20
64	Gas/Wood/Other Biomass/Liquid FF	2	80	20
65	Gas/Wood/Other Biomass/Liquid FF	1	80	20
66	Distillate Liquid FF	407	60	40
67	Distillate Liquid FF	210	60	40
68	Distillate Liquid FF	42	60	40
69	Distillate Liquid FF	13	60	40
70	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	3	100	0
72	NFF Liquid/NFF Solid or Gas/NFF Liquid/NFF Solid	1	100	0
73	Wood	14	80	20
74	Wood	8	80	20
75	Wood	1	80	20
76	Wood	3	80	20
77	Wood	2	80	20
78	Wood/Other Biomass/NFF Liquid/NFF Solid	2	80	20
79	Wood/Other Biomass/NFF Liquid/NFF Solid	4	80	20
80	Residual Liquid FF	159	75	25
81	Residual Liquid FF	304	75	25
82	Residual Liquid FF	63	75	25
83	Residual Liquid FF	7	75	25

Appendix B

Example Calculations

Appendix B

Example Fuel Consumption Difference Calculation - 2005 Natural Gas, Industrial Sector:

The percent difference from 1998 to 2005 for natural gas for the is calculated using the following equation:

$$PC\_x\_TY = \left(\left(EIA\_FC\_x\_TY - EIA\_FC\_x\_1998 \right) / EIA\_FC\_x\_1998 \right) \times 100$$

The percent difference is calculated to be 6.3 % by substituting the appropriate values for the industrial sector from table 3-1 yields (see below):

$$6.3\% = \left(\left(10.36 quadsBtu - 9.75 quadsBtu \right) / 9.75 quadsBtu \right) \times 100$$

Example New Boiler Calculation - Model #14, Industrial Sector:

The model units memorandum[1] gives the following information regarding model #14: Average capacity = 33 MMBtu/hr; Capacity factor = 0.63; Total number of units in 1998 = 10.039.

Calculate number of boilers in industrial sector:

From the data in appendix A, 60 % of the boilers assigned to model #14 are within the industrial sector. Therefore 10.039*0.6 = 6.023 units are assigned to model #14 within the industrial sector.

Calculate 1998 fuel consumption for model and sector:

The equation used to calculate 1998 fuel consumption by model boiler and sector is given by the following equation:

$$FC\_x\_1998 = (AC)(CU)(N_{i,c})(FF\_x)(8760)$$

A 1998 fuel consumption of 1.097×10^9 MMBtu is calculated by substituting the appropriate model parameters and number of units into the above equation, as follows:

$$1.097 \times 10^9 \text{ MMBtu} = (33\text{MMBtu})(0.63)(6.023)(1.00)(8760)$$

Forecast annual fuel consumption for model and sector:

As calculated at the beginning of this example, there is an anticipated 6.3 % increase in natural gas for the industrial sector in 2005. This information and the 1998 fuel consumption are inserted in the following equation to forecast the 2005 fuel consumption for this model and sector:

$$FC\_x\_TY = (FC\_x\_1998)\left(1 + \left(PC\_x\_TY/100\right)\right)$$

Substituting the appropriate values yields a fuel consumption of 1.2 x 10^9 MMBtu of natural gas for model #14, industrial sector for 2005 (see following).

$$1.166 \times 10^9 \text{ MMBtu} = (1.097 \times 10^9 \text{ MMBtu})\left(1 + \left(6.3/100\right)\right)$$

As noted previously, model #14 only combusts natural gas, so that the fuel consumption of natural gas is equal to the total fuel consumption of boilers assigned to this model.

Calculation of units:

The number of units in a target year is given by the following equation:

$$NU\_TY = \left(\frac{TFC\_TY}{(AC)(CU)(8760)}\right)$$

By inserting the values for this model and sector for 2005, the following number of units for 2005 is obtained:

$$6{,}400 = \left(\frac{1.166 \times 10^9\ MMBtu}{(33\ MMBtu)(0.63)(8760)}\right)$$

Calculation of new units:

New units are calculated simply by subtracting the number of units for the model and sector in 1998 from the number of units calculated for the target year. In this example, the number of new boilers assigned to model #14 for the industrial sector for year 2005 is 6,400 - 6,023 = 377.